PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Increased Mortality Rates of Young Children With Traumatic Injuries at a US Army Combat Support Hospital in Baghdad, Iraq, 2004

Renée I. Matos, John B. Holcomb, Charles Callahan and Philip C. Spinella
Pediatrics 2008;122;e959-e966
DOI: 10.1542/peds.2008-1244

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://www.pediatrics.org/cgi/content/full/122/5/e959

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **NOV 2008**	2. REPORT TYPE	3. DATES COVERED **00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE **Increased Mortality Rates of Young Children With Traumatic Injuries at a US Army Combat Support Hospital in Baghdad, Iraq, 2004**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Wilford Hall Medical Center,Department of Pediatrics,2200 Bergquist Dr,Lackland AFB,TX,78236**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**10**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

ARTICLE

Increased Mortality Rates of Young Children With Traumatic Injuries at a US Army Combat Support Hospital in Baghdad, Iraq, 2004

Renée I. Matos, MD[a], John B. Holcomb, MD[b], Charles Callahan, DO[c], Philip C. Spinella, MD[b,d]

[a]Department of Pediatrics, Wilford Hall Medical Center, Lackland Air Force Base, Texas; [b]US Army Institute of Surgical Research, Brook Army Medical Center, San Antonio, Texas; [c]Walter Reed Army Medical Center, Washington, DC; [d]Department of Pediatrics, Connecticut Children's Medical Center, Hartford, Connecticut

The authors have indicated they have no financial relationships relevant to this article to disclose.

What's Known on This Subject

Pediatric trauma victims in Iraq are frequently admitted to US military facilities with high mortality rates and use a great deal of resources. In the United States, studies have not found a difference between pediatric and adult blunt trauma mortality rates.

What This Study Adds

We evaluated the affect of young age on mortality in penetrating traumatic injury during wartime and showed an independent increased risk for mortality in children and used an age of ≤8 as physiologically different to distinguish pediatric versus adult trauma care.

ABSTRACT

OBJECTIVE. The objective of this study was to determine whether age ≤8 y is an independent predictor of mortality in noncoalition trauma patients at a US combat support hospital.

METHODS. A retrospective chart review was conducted of 1132 noncoalition trauma patients who were admitted to a combat support hospital between December 2003 and December 2004. Data on age, severity of injury indices, and in-hospital mortality rates were analyzed. All variables that were associated with death on univariate analysis were analyzed by multivariate logistic regression to determine independent associations with mortality.

RESULTS. There were 38 young pediatric patients (aged ≤8 years) and 1094 older pediatric and adult patients (aged >8 years). Penetrating trauma accounted for 83% of all injuries. Young pediatric patients compared with older pediatric and adult patients had increased severity of injury indicated by decreased Glasgow Coma Scale score; increased incidence of hypotension, base deficit, and serum pH on admission; red blood cell transfusion amount; and increased injury severity scores on admission. Young pediatric patients compared with older pediatric and adult patients also had increased ICU lengths of stay (median 2 [interquartile range 0–5] vs median 0 [interquartile range 0–2] days) and in-hospital mortality rate (18% vs 4%), respectively. Multivariate logistic regression indicated that base deficit, injury severity score of ≥15, Glasgow Coma Scale score of ≤8, and age of ≤8 years were independently associated with mortality.

CONCLUSIONS. Young children who present to a combat support hospital have increased severity of injury compared with older children and adults. In a population with primarily penetrating injuries, after adjustment for severity of injury, young children may also have an independent increased risk for death compared with older children and adults. Providing forward-deployed medical staff with pediatric-specific equipment and training in the acute care of young children with severe traumatic injuries may improve outcomes in this population. *Pediatrics* 2008;122:e959–e966

www.pediatrics.org/cgi/doi/10.1542/peds.2008-1244

doi:10.1542/peds.2008-1244

The views and opinions expressed in this article are those of the authors and do not reflect the official policy or position of the Army Medical Department, Department of the Army, Department of the Air Force, the Department of Defense, or the US government.

Key Words
pediatric, trauma, mortality, survival, combat, penetrating

Abbreviations
CSH—combat support hospital
PALS—Pediatric Advanced Life Support
ISS—injury severity score
AIS—Abbreviated Injury Scale
IQR—interquartile range
GCS—Glasgow Coma Scale

Accepted for publication Jul 31, 2008

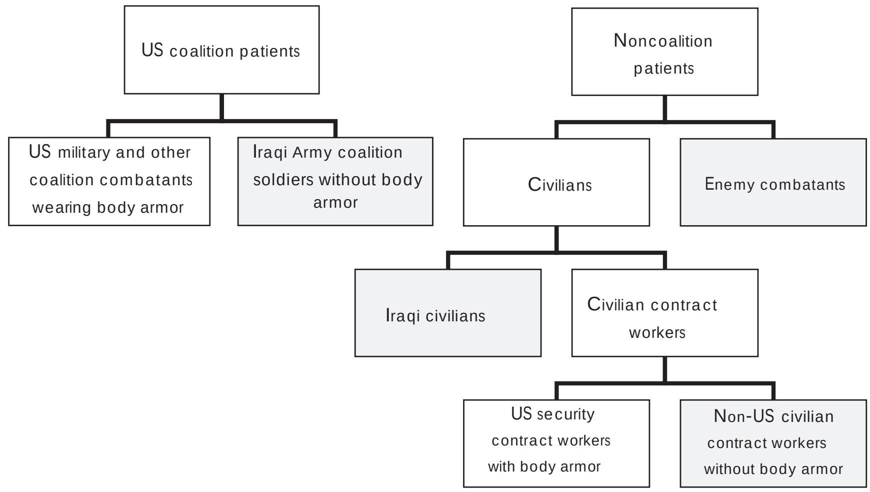
Address correspondence to Renée I. Matos, MD, Department of Pediatrics, 2200 Bergquist Dr, Suite 1, Lackland Air Force Base, TX 78236. E-mail: reneedlt@gmail.com

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Trauma remains the leading cause of childhood mortality, accounting for >15 000 deaths annually in the United States.[1] During wartime, including the current conflict in Iraq, pediatric injuries and death as a result of trauma are an unfortunate yet often unavoidable tragedy. Modern warfare has changed in such a way that children frequently become victims of crossfire injuries and improvised explosive devices. In contrast to trauma in the United States, injuries that are sustained in combat are predominantly penetrating, rather than blunt.[2–6]

The US Army has established many combat support hospitals (CSHs) in Iraq to provide medical care to US military personnel. In addition, the US military medical mission includes providing care to all patients, regardless of personnel status, who have injuries that are threatening to life, limb, or eyesight. As a result, the US medical facilities in Iraq have cared for thousands of Iraqi patients, both children and adults.[2,4,6–11] Patients present to these facilities with both

FIGURE 1
Patient groups (shaded boxes) were included in this study because they all did not wear body armor and were not routinely transferred out of Iraq to higher levels of medical care. These patients also all remained at the CSH until they were hemodynamically stable, did not require mechanical ventilation, and did not require additional significant operative intervention.



traumatic and medical illnesses. Although many of the traumatic injuries are combat related, some injuries are accidental and non–combat related.

According to recent reports, 40% of all admissions and 70% of hospital bed days at US military hospitals in Iraq and Afghanistan are civilian patients.[9] Published data indicate that these patients, including enemy combatants, have received the same level of care as US soldiers.[9] Recent data also indicate that 4% of all admissions to Army CSHs in Iraq and Afghanistan are children (younger than 18 years) and account for 10% of all hospital bed days.[7] Another report suggested not only that pediatric trauma patients are admitted to Army CSHs in both Iraq and Afghanistan with increased severity of injury compared with adults, but also that there is an increased unadjusted mortality risk for children who are younger than 6 years compared with children who are ≥6 years of age in this population.[12] Providing care to severely injured children by a medical system that is designed primarily to care for adult traumatic injuries has been a challenge for the US Army, which, as a result, has made many adjustments during these recent conflicts to improve the care that is delivered to children with traumatic injuries.[9]

In an effort to determine whether the increased incidence of mortality in young children, noted in previous reports,[12] was related to the increased severity of injury or other potential factors, we performed this study. Our objective was to determine whether young children are at increased risk for death compared with older children and adults with traumatic injuries during combat.

METHODS

Patients

The cohort for this institutional review board–approved retrospective review was derived from the 31st CSH trauma database, which includes all patients, both military and civilian, who were treated at the 31st CSH in Iraq between December 2003 and December 2004. The 31st CSH was located in Baghdad, Iraq, and served as the only neurotrauma center for the country during the period of this study. This study included only civilians and combatants who were not wearing body armor (Fig 1). US soldiers and other coalition soldiers with body armor were excluded from the study, because the use of body armor and the practice of rapidly transporting these patients to higher levels of care outside Iraq would bias our primary outcome measurement of in-hospital mortality. Noncoalition patients are defined to include enemy combatants and all civilians, and these patients received treatment at the nearest American or coalition medical facility when their injuries were threatening to life, limb, or eyesight. They also did not wear body armor; remained at the CSH for treatment; and were not transferred to local facilities until they were hemodynamically stable, did not require mechanical ventilation, and did not require additional significant operative intervention.[8]

Patients were divided into 2 groups on the basis of age of ≤8 years ("young children") and age >8 years ("older children and adults"). This definition was supported by visual inspection of the relationship between age and mortality by using the US Army Patient Administration Systems and Biostatistics Activity database, which includes ~19 000 trauma patients and 1300 patients who are younger than 18 years (data not shown). The Patient Administration Systems and Biostatistics Activity database is an epidemiologic database that is maintained by the US Army and includes all patients who were admitted to CSHs in Iraq and Afghanistan. Recent literature also supports using 8 years of age to categorize pediatric patients on the basis of the concept that physiology is age dependent in children.[13,14] In addition, the lay rescuer definition of a child is 1 to 8 years of age according to current 2005 Pediatric Advanced Life Support (PALS) guidelines.[15]

Penetrating injuries were categorized as either from gun shot wounds or from explosive devices. Explosive devices included injuries secondary to shrapnel from grenades, rockets, or any other type of improvised explosive device. The injury severity score (ISS) and Ab-

breviated Injury Scale (AIS) score were calculated by trained staff at the US Army Institute of Surgical Research according to standard methods.[16] Primary outcome for all patients in this study was in-hospital mortality, which was recorded until time of hospital transfer or discharge. Data that vary by age, including heart rate, blood pressure, and hematocrit, were analyzed as dichotomous variables to allow for definitions that vary with age. For adults, bradycardia was defined as heart rate of <60 beats per minute and tachycardia as a heart rate of >100 beats per minute,[17] whereas for children, heart-rate parameters were based on defined values for age.[18] Hypotension was defined on the basis of current PALS guidelines by using systolic blood pressure of <70 mm Hg for patients <1 year old and <70 mm Hg + (2 × age in years) for patients 1 to <10 years old and systolic blood pressure of <90 mm Hg for all patients >10 years old.[15] Anemia was defined as <2 SDs below the mean for age.[19] For all age groups, hypothermia was defined as admission temperature of <36°C.[20] Anatomic and physiologic causes of death were categorized by 1 investigator according to data available in the chart.

Statistical Analysis

Parametric data are presented as means ± SD. Nonparametric data are presented as median (interquartile range [IQR]) and mean. Student's *t* test was used to compare parametric continuous data. The Wilcoxon rank-sum test was used to compare nonparametric continuous data. Categorical data were compared by using χ^2 test or Fisher's exact test as appropriate. Multivariate logistic regression was then used to determine which variables were independently associated with mortality by initially including all variables with a $P < .1$. All tests are 2-sided, and significance for all comparisons was set at $P \leq .05$. Statistical analysis was performed by using SPSS 15.0 (SPSS, Inc, Chicago, IL).

RESULTS

A total of 1132 patients met inclusion criteria and were admitted to the CSH between December 2003 and December 2004. Thirty-eight (3.4%) of these patients were ≤8 years, and 1094 (96.6%) were >8 years. The incidence of penetrating injuries was 24 (63%) of 38 in young children and 778 (83%) of 923 in older children and adults ($P = .001$). Ten (42%) of 24 penetrating injuries in young children were gunshot wounds, and 14 (58%) of 24 were explosive device injuries. Isolated blunt trauma accounted for 13 (34%) of the injuries in young children and 134 (15%) in older children and adults. The remaining young pediatric patients had a 26% body surface area second- and third-degree burns from an accidental hot-water injury. Young children were less likely to be male than older children and adults (58% vs 96%, respectively; $P < .001$; Table 1). In addition, young children (≤8 years) were less likely to be male compared with older children (9–17 years; 22 [58%] of 38 vs 59 [89%] of 66, respectively; $P < .001$). No young children were classified as enemy combatants, whereas 10 (15%) of 66 older children (9–17 years)

TABLE 1 **Comparison of Variables Between Study Groups**

Variable	Young Children Aged ≤8 y (*N* = 38)	Older Children and Adults Aged >8 y (*N* = 1094)	*P*
Age, y			<.001
Median (IQR)	5 (4–6)	30 (23–37)	
Mean	5	31	
Male, *n*/*N* (%)	22/38 (58)	1050/1094 (96)	<.001
Penetrating injuries, *n*/*N* (%)	24/38 (63)	778/923 (84)	.001
Hypotension, *n*/*N* (%)	5/37 (14)	48/1086 (4)	.027
Bradycardia, *n*/*N* (%)	0/38 (0)	25/1090 (2)	.999
Tachycardia, *n*/*N* (%)	14/38 (37)	437/1090 (40)	.739
Temperature, mean ± SD, °F	98.5 ± 3.0	97.9 ± 1.9	.110
Hypothermia (temperature <36°C), *n*/*N* (%)	6/32 (19)	185/968 (19)	.999
GCS			
Median (IQR)	14 (12)	15 (0)	
Mean	11	14	<.001
GCS ≤8	10/37 (27)	115/1062 (11)	.006
Hematocrit, mean ± SD, %	30 ± 9	38 ± 8	<.001
Anemia	20/28 (71)	462/875 (53)	.056
pH, mean ± SD	7.23 ± 0.18	7.31 ± 0.10	<.001
Base deficit			
Median (IQR)	7.5 (3.8–11.0)	2.0 (0.0–5.0)	
Mean	8.0	3.8	<.001
RBCs, U			
Median (IQR)	0.5 (0.0–2.0)	0.0 (0.0–0.0)	
Mean	1.2	1.1	.004
FFP			
Median (IQR)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	
Mean	0.6	0.5	.139
Whole blood			
Median (IQR)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	
Mean	0.1	0.1	.787
ICU length of stay, d			
Median (IQR)	2.0 (0–5.0)	0.0 (0.0–2.0)	
Mean	4.0	2.0	<.001
Hospital length of stay, d			
Median (IQR)	4.0 (2.0–9.0)	4.0 (2.0–9.0)	
Mean	7.9	8.0	.620
ISS			
Median (IQR)	13.0 (5.0–20.0)	9.0 (4.0–13.0)	
Mean	15.0	10.0	.002
ISS ≥15, *n*/*N* (%)	15/38 (39)	214/1073 (20)	.007
AIS			
Head			
Median (IQR)	0.0 (0.0–4.0)	0.0 (0.0–0.0)	
Mean	1.7	0.6	<.001
Face			
Median (IQR)	0.0 (0.0–1.0)	0.0 (0.0–0.0)	
Mean	0.5	0.2	.051
Thorax			
Median (IQR)	0.0 (0.0–0.3)	0.0 (0.0–0.0)	
Mean	0.6	0.5	.408
Abdomen			
Median (IQR)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	
Mean	0.2	0.5	.224
Pelvis/extremity			
Median (IQR)	0.0 (0.0–1.0)	1.0 (0.0–3.0)	
Mean	0.7	1.3	.011
External			
Median (IQR)	0.0 (0.0–1.0)	0.0 (0.0–1.0)	
Mean	0.9	0.6	.984
Overall mortality, *n*/*N* (%)	7/38 (18)	42/1094 (4)	.001

RBCs indicates red blood cells; FFP, fresh-frozen plasma.

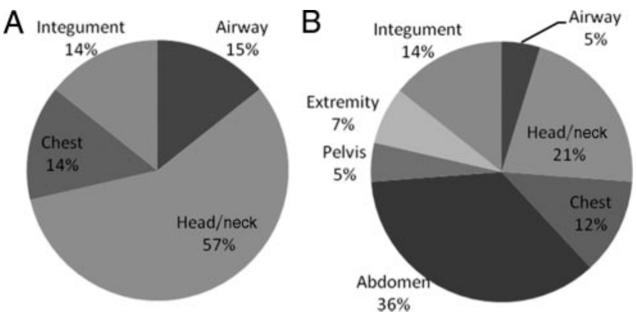


FIGURE 2
Anatomic causes of death for each age group. A, Age ≤ 8 years ($n = 7$). B, Age > 8 years ($n = 42$). $P > .05$ for all comparisons of injury location between groups.

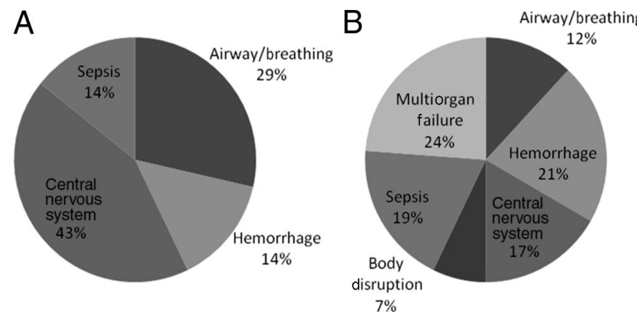


FIGURE 3
Physiologic causes of death for each age group. A, Age ≤ 8 years ($n = 7$). B, Age > 8 years ($n = 42$). $P > .05$ for all comparisons of physiologic causes of death between groups.

were classified as enemy combatants. All of the children who were classified as enemy combatants were male and had 100% survival.

Table 1 summarizes admission vital signs and laboratory values, in addition to other descriptive characteristics and indicators of severity of injury for each of the 2 age groups. Younger children (aged ≤8 years) were more likely to have increased severity of injury on the basis of admission vital signs, laboratory values, Glasgow Coma Scale (GCS) score, red blood cell transfusion requirement, and ISS. Increased severity of injury in young children compared with older children and adults is also indicated by a higher incidence of severe traumatic injury (ISS ≥15; 39% vs 20%, respectively; $P = .007$) and increased mean head AIS values (1.7 vs 0.6, respectively; $P < .001$). In-hospital mortality was increased in the younger children compared with the older children and adults (18% vs 4%, respectively; $P = .001$). For patients who died, the length of time they remained alive was similar for young children (median: 3 days [IQR: 1–9 days]) compared with older children and adults (median: 3 days [IQR: 1–5 days]; $P = .51$). Anatomic and physiologic causes of death for both groups of patients are displayed in Figs 2 and 3, respectively, although neither was significantly different when compared.

Mortality for each age group is displayed in Fig 4. For patients between the ages of 9 and 40, mortality ranged between 2.5% and 5.3% and was similar between all patient age categories ($P = .98$). Mortality was increased in older adults (≥40 years) compared with older children and young adults (9–39 years; 14 [6.1%] of 228 vs 25 [3.1%] of 800, respectively; $P = .04$; Fig 4).

Table 2 compares the characteristics of patients who survived with those who did not. Younger patients had higher in-hospital mortality (14% vs 3%, respectively; $P = .001$). Patients who died were more likely to have hypotension (22% vs 4%), tachycardia (65% vs 39%), and hypothermia (53% vs 18%; $P < .001$). They were also more likely to have an elevated base deficit; have a low pH; and require more red blood cells, fresh-frozen plasma, and whole blood ($P < .001$). Patients who died were also more likely to have a GCS score of ≤8 (56% vs 9%) and an ISS ≥15 (69% vs 18%; $P < .001$). AISs suggest that head, thorax, and abdominal injuries were significantly worse in patients who died, whereas pelvic/extremity injuries were less severe. Variables that were included in the multivariate logistic regression analysis were age ≤8 years; hypotension; tachycardia; hypothermia; GCS score of ≤8; base deficit; pH; hematocrit; units of blood products transfused; head, thorax, abdomen, and pelvis/extremity AIS; and ISS ≥15. Only pH was eliminated from the model because of co-linearity with base deficit. Variables that were determined to be independently associated with in-hospital mortality were base deficit, GCS score of ≤8, ISS ≥15, and age ≤8 years (Table 3). As a measure of accuracy, the area under the curve was 0.86 for our regression model, which was calculated by using predicted probabilities and receiver operator curve analysis.

DISCUSSION

This is the first study to compare outcomes, with adjustment for severity of injury, of children with older patients with traumatic injuries at a CSH. Our results indicate that children who were ≤8 years of age presented to the CSH with increased severity of injury. More important, with adjustment for severity of injury by multivariate logistic regression analysis, age ≤8 years was determined to be independently associated with an increased risk for in-hospital mortality. The use of body armor and differences in transport or referral times were not considered, because US military patients and all others with body armor were excluded from our study.

Young children may have increased severity of injury compared with older children and adults for many reasons. It is possible that children who were ≤8 years had increased severity of injury given that the primary mechanism involved was most commonly the result of penetrating injuries. Explosion injuries are more likely to affect a larger proportion of body surface area in younger children compared with older children and adults. In addition, with penetrating injury, it is possible that the risk for severe bleeding may be increased in children because of decreased blood volumes. As a result, younger children may have increased risk for hemorrhagic shock when compared with older children and adults. The increased base deficit as a reflection of hypoperfusion or shock in young children compared with older children and adults supports this possibility. An-

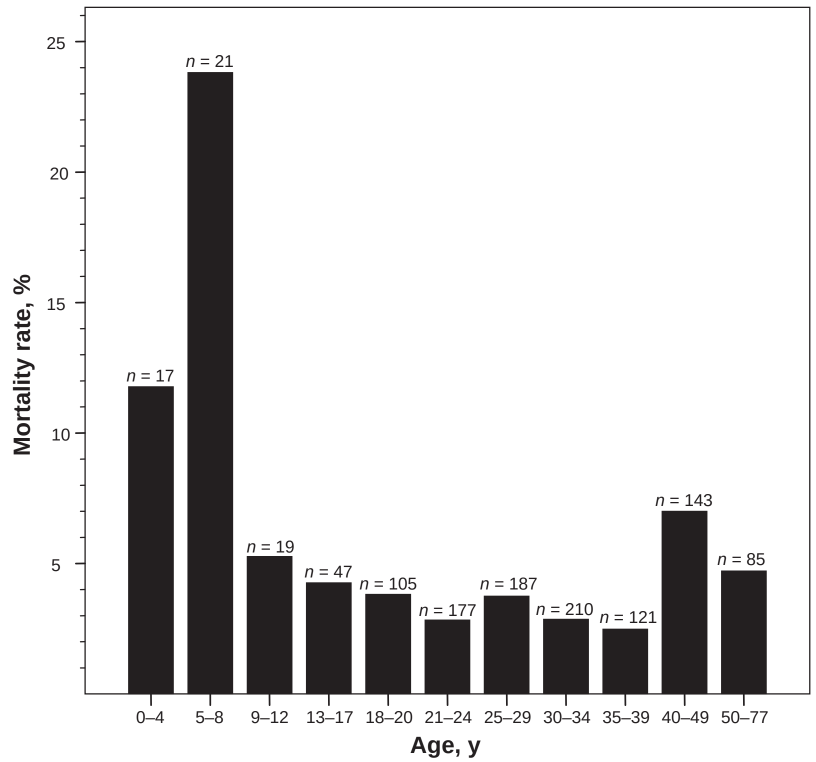


FIGURE 4
Mortality of patients according to age. Mortality rates were greater for patients who were ≤8 years old (18%) compared with patients who were 9 to 77 years old (4%) ($P = .001$). Mortality rates were greater for patients who were 40 to 77 years old (6%) compared with those who were 9 to 39 years old (3%) ($P = .04$).

other potential factor is that children may be closer to explosions than adult civilians as a result of their proximity to soldiers. Young children, especially boys, often congregate around soldiers out of curiosity and unfortunately are injured concurrently when soldiers are targeted. The loss of male dominance in the young child group even compared with older children is potentially a result of the randomness of injuries that occur to young children, whereas older male children are more likely to be involved in combat-related activities. This is supported by our findings that 15% of older children were identified as enemy combatants. The incidence of older children who were directly involved with engaging enemy combatants was not able to be measured.

The young children in our study who died had increased head, neck, and airway injuries compared with older children and adults, although these differences were not statistically significant. Because autopsies were not performed on these patients, we were not able to determine whether any of the fatal injuries in this study were potentially survivable. Although it is possible that young children had an increased incidence of nonsurvivable head, neck, and airway injuries compared with older children and adults, our regression analysis does include abbreviated ISSs for head and neck location, which may have adequately adjusted for the increased incidence of death as a result of injuries in this location.

Our findings of an independent risk for increased mortality in young children ≤8 years of age may be influenced by many factors. We were not able to determine the specific causes of the increased risk for mortality independent of severity of injury to young children in our retrospective study. It is possible that young children with significant traumatic injuries require care that is provided by a multidisciplinary team that is trained in pediatric critical care to decrease the risk for mortality. Our patients, both children and adults, were cared for primarily by adult care providers to include nurses, respiratory therapists, critical care physicians, anesthesiologists, and surgeons. A pediatric intensivist (Dr Spinella) was available only on an intermittent basis to consult for a few hours a day on the care provided for all children who were admitted to the CSH during the time of this study. No pediatric trained personnel (physician, nurse, or respiratory therapist) were stationed at the CSH at the time these data were collected; neither was a complete set of pediatric resuscitative equipment available.

Several previous studies that did not adjust for injury severity compared pediatric with adult mortality for specific types of trauma. Each of these studies indicated that pediatric patients (aged <18 years) have reduced mortality when compared with adult patients.[21–26] It is also possible that the differences found in these studies are related to the effects of blunt versus penetrating trauma in young children. Previous studies of pediatric patients who had primarily blunt trauma and were cared for in adult trauma centers, even after adjustment for severity of injury, did not report an increased risk for death in children[27–31]; however, other, more recent studies compared care of pediatric trauma patients in adult versus pediatric trauma centers and found improved outcomes at pediatric trauma centers.[32–35] The American Academy of Pediatrics recently published a policy statement on the management of pediatric trauma that supports that age-specific trauma resources and qualified personnel are particularly important for the youngest and most se-

TABLE 2 Comparison of Variables Between Survivors and Nonsurvivors

Variable	Survivors ($N = 1083$)	Nonsurvivors ($N = 49$)	*P*
Age, mean ± SD, y	30 ± 12	28 ± 14	.508
Age ≤8, *n/N* (%)	31/1083 (3)	7/49 (14)	.001
Age <18, *n/N* (%)	94/1083 (9)	10/49 (20)	.011
Male, *n/N* (%)	1027/1083 (95)	45/49 (92)	.324
Penetrating injuries, *n/N* (%)	769/919 (84)	33/44 (75)	.190
Hypotension, *n/N* (%)	43/1077 (4)	10/46 (22)	<.001
Bradycardia, *n/N* (%)	24/1079 (2)	1/49 (2)	1.000
Tachycardia, *n/N* (%)	419/1079 (39)	32/49 (65)	<.001
Temperature, mean ± SD, °F	98.0 ± 1.9	96.1 ± 3.6	<.001
Hypothermic (temperature < 36°C), *n/N* (%)	173/966 (18)	18/34 (53)	<.001
GCS			
Median (IQR)	15 (15–15)	3 (3–15)	
Mean	14	8	<.001
GCS ≤ 8, *n/N* (%)	100/1054 (9)	25/45 (56)	<.001
Hematocrit, %			
Median (IQR)	39.00 (33.00–44.00)	35.00 (24.00–44.00)	
Mean	38.00	34.00	.018
Anemia, *n/N* (%)	453/858 (53)	29/45 (64)	.167
Base deficit			
Median (IQR)	2.00 (0.00–5.00)	8.00 (4.00–16.50)	
Mean	3.50	11.00	<.001
pH, mean ± SD	7.32 ± 0.09	7.18 ± 0.19	<.001
RBCs, U			
Median (IQR)	0.00 (0.00–0.00)	2.00 (0.00–6.50)	
Mean	1.00	5.00	<.001
FFP			
Median (IQR)	0.00 (0.00–0.00)	0.00 (0.00–2.50)	
Mean	0.44	2.80	<.001
Whole blood			
Median (IQR)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Mean	0.06	0.69	<.001
ICU length of stay, d			
Median (IQR)	0.00 (0.00–2.00)	3.00 (1.00–8.00)	
Mean	2.32	6.82	<.001
ISS			
Median (IQR)	9.00 (4.00–13.00)	18.50 (11.50–26.00)	
Mean	9.00	23.00	<.001
ISS ≥ 15, *n/N* (%)	196/1063 (18)	33/48 (69)	<.001
AIS			
Head			
Median (IQR)	0.00 (0.00–0.00)	0.00 (0.00–3.75)	
Mean	0.55	1.33	.003
Face			
Median (IQR)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Mean	0.25	0.17	.168
Thorax			
Median (IQR)	0.00 (0.00–0.00)	0.00 (0.00–1.00)	
Mean	0.48	0.81	.047
Abdomen			
Median (IQR)	0.00 (0.00–0.00)	0.00 (0.00–2.00)	
Mean	0.45	1.00	.001
Pelvis/extremity			
Median (IQR)	1.00 (0.00–3.00)	0.00 (0.00–1.75)	
Mean	1.33	0.85	.010
External			
Median (IQR)	0.00 (0.00–1.00)	0.00 (0.00–1.00)	
Mean	0.58	1.29	.833

RBCs indicates red blood cells; FFP, fresh-frozen plasma.

TABLE 3 Variables Independently Associated with In-Hospital Mortality According to Multivariate Logistic Regression

Variable	OR (95% CI)	*P*
Base deficit	1.13 (1.06–1.20)	<.001
ISS ≥ 15	3.22 (1.29–8.06)	.012
GCS ≤ 8	3.33 (1.45–7.65)	.005
Age ≤ 8 y	3.61 (1.09–11.96)	.036

Additional variables that were included in the multivariate logistic regression analysis and were not significant were hypotension; tachycardia; hypothermia; hematocrit; red blood cell units transfused; and head, thorax, abdomen, and pelvis/extremity AIS. OR indicates odds ratio; CI, confidence interval.

verely injured children.[36] It is not possible for us to determine whether the independent increased risk for in-hospital mortality for young children at our CSH was affected by the level of pediatric experience of the providers who cared for these Iraqi children; however, considering these recent studies that support a benefit to providing trauma care to children at pediatric trauma centers that are staffed with providers who are trained in the care of critically ill children, this is a possible explanation of our findings. In addition, differences in our results compared with previous results may be related to our definition of a child. Rather than using the more common definition of a child (<18 years), we chose 8 years of age on the basis of the greater disparity in physiologic and anatomic differences with patients who are older than 8 years in general. Additional study is needed to determine whether defining children as younger than 8 years is more predictive of outcome and would more accurately represent an age category that is physiologically and anatomically more precise than the standard definition.

To improve the care that is provided to children of all ages at US Army CSHs, many adjustments have been made since the initiation of the war in Iraq. Previously, pediatricians were deployed exclusively as general medical officers or in medical leadership administrative positions; however, as a result of the increased number of pediatric patients, pediatricians have recently been added to the staff of certain CSHs with a high load of pediatric admissions. In addition, there is now a telemedicine system that provides level II and III facilities with immediate access to a pediatric intensivist by telephone or e-mail, and a complete supply set of pediatric-specific equipment and medications that can be easily ordered by CSH logisticians have been established.[8,9] In addition, since September 2005, the staff of many CSHs have received pediatric-specific predeployment trauma training at military medical centers.[9] Another method that may also improve the care of pediatric patients is to take advantage of the technology of "robotic telepresence" to assist military providers in providing care to pediatric patients in deployed military hospitals.[37]

Limitations of our study primarily include those that are inherent to retrospective studies. The lack of randomization and blinding of study groups is an issue with all retrospective studies. The possibility that we were not able to adjust for all potential confounding variables that may have affected in-hospital mortality is also a primary

limitation of this study. Despite this limitation, that 14 potential variables were included in the analysis and results of an area under the curve for our logistic regression model of 0.86 indicates that we were able to produce robust results. Another limitation is that we were unable to calculate 30-day mortality because some patients were transferred to Iraqi facilities once stable and no longer requiring vasoactive agents, mechanical ventilation, or significant additional operative interventions. In addition, our study was limited by the small patient population in the group of children who were ≤8 years of age, which may have introduced sampling bias into our results. Finally, we chose to categorize patients according to age, because this information was available, but perhaps it would have been more appropriate to use normalized weight for height instead. As a result of a wide variation of patient weight according to age, patient-normalized weight may be a more accurate indicator of physiologic maturity. In general, PALS curriculum supports a weight-based approach to guide treatment of children.[15] Unfortunately, we were not able to record accurate weights for all patients in our study.

Despite these limitations, this study is still the first to evaluate the affect of young age on mortality in patients with traumatic injury during wartime. It is also the first study to show an independent increased risk for mortality among young children when compared with older children and adult trauma victims. Although the number of children in this study was low, the number of young children who were ≤8 years of age and treated at all deployed US CSHs between November 2001 and January 2007 is >500 patients.[7,9] In Baghdad, a city of ~5 million people, during 2004 there were only enough resources to support a 4-bed PICU during a year in which 1500 pediatric deaths were estimated in the city (P.C.S., verbal communication, 2005). With the inherent risks of the "full-spectrum operations," including peace operations, that we can anticipate as a nation over the coming decades, the need to care for pediatric trauma victims in military hospitals is very likely.[38] Our analysis provides compelling evidence that US Army CSHs and their equivalents in other services will best serve the children of the nations where they operate by providing proper personnel, pediatric-specific training, and pediatric-specific equipment.

CONCLUSIONS

In combat, young children have increased severity of injury compared with older children and adults. In a population with primarily penetrating injuries, after adjustment for severity of injury, young children may also have an independent increased risk for death compared with older children and adults. Many changes have been made to improve the care that is provided to young children at Army CSHs since the initiation of the war in Iraq. The use of medical staff who are specifically trained in the acute care of young children with severe traumatic injuries may improve outcomes in this population. Additional study is needed to determine whether young children with penetrating injury are at increased risk for mortality at facilities (military and civilian) that are not staffed by providers who are trained in pediatric critical care.

REFERENCES

1. Heron MP. Deaths: leading causes for 2004. *Natl Vital Stat Rep.* 2007;56(5):1–95
2. Gawande A. Casualties of war: military care for the wounded from Iraq and Afghanistan. *N Engl J Med.* 2004;351(24): 2471–2475
3. Patel TH, Wenner KA, Price SA, Weber MA, Leveridge A, McAtee SJ. A U.S. Army forward surgical team's experience in Operation Iraqi Freedom. *J Trauma.* 2004;57(2):201–207
4. Cho JM, Jatoi I, Alarcon AS, Morton TM, King BT, Hermann JM. Operation Iraqi Freedom: surgical experience of the 212th Mobile Army Surgical Hospital. *Mil Med.* 2005;170(4):268–272
5. Montgomery SP, Swiecki CW, Shriver CD. The evaluation of casualties from Operation Iraqi Freedom on return to the continental United States from March to June 2003. *J Am Coll Surg.* 2005;201(1):7–13
6. Coppola CP, Leininger BE, Rasmussen TE, Smith DL. Children treated at an expeditionary military hospital in Iraq. *Arch Pediatr Adolesc Med.* 2006;160(9):972–976
7. Spinella PC, Borgman MA, Azarow KS. Pediatric trauma in an austere combat environment. *Crit Care Med.* 2008;36(7 suppl): S293–S296
8. McGuigan R, Spinella PC, Beekley A, et al. Pediatric trauma: experience of a combat support hospital in Iraq. *J Pediatr Surg.* 2007;42(1):207–210
9. Burnett MW, Spinella PC, Azarow KS, Callahan CW. Pediatric care as part of the US Army medical mission in the global war on terrorism in Afghanistan and Iraq, December 2001 to December 2004. *Pediatrics.* 2008;121(2):261–265
10. Stout LR, Jezior JR, Melton LP, et al. Wartime burn care in Iraq: 28th Combat Support Hospital, 2003. *Mil Med.* 2007; 172(11):1148–1153
11. Winslow DL. Treating the enemy. *Ann Intern Med.* 2007;147(4): 278–279
12. Spinella PC, Borgman MA, Azarow KS. Pediatric trauma in an austere combat environment. *Crit Care Med.* 2008;36(suppl 7): S293–S296
13. Meaney PA, Nadkarni VM, Cook EF, et al. Higher survival rates among younger patients after pediatric intensive care unit cardiac arrests. *Pediatrics.* 2006;118(6):2424–2433
14. Samson RA, Nadkarni VM, Meaney PA, Carey SM, Berg MD, Berg RA. Outcomes of in-hospital ventricular fibrillation in children. *N Engl J Med.* 2006;354(22):2328–2339
15. Ralston M, Hazinski MF, Zaritsky AL, Schexnayder SM, Kleinman ME, eds. *Pediatric Advanced Life Support Provider Manual*. Dallas, TX: American Heart Association; 2006
16. Baker SP, O'Neill BB, Haddon WJ, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma.* 1974;14(3): 187–196
17. Kossman CE. The normal electrocardiogram. *Circulation.* 1953; 8(6):920–936
18. Robertson J, Shilkofski N, eds. *The Harriet Lane Handbook: A Manual for Pediatric House Officers*. 17th ed. Philadelphia, PA: Mosby; 2005
19. Nathan DG, Ginsburg D, Orkin SH, Look AT, eds. *Nathan and Oski's Hematology of Infancy and Childhood*. 6th ed. Philadelphia, PA: WB Saunders Co; 2003
20. Arthurs Z, Cuadrado D, Beekley A, et al. The impact of hypothermia on trauma care at the 31st combat support hospital. *Am J Surg.* 2006;191(5):610–614
21. Luerssen T, Klauber M, Marshall L. Outcome from head injury related to patient's age: a longitudinal prospective study of

adult and pediatric head injury. *J Neurosurg.* 1988;68(3):409–416
22. Snyder CL, Jain VN, Saltzman DA, Strate RG, Perry JF, Leonard AS. Blunt trauma in adults and children: a comparative analysis. *J Trauma.* 1990;30(10):1239–1245
23. Ismail N, Bellemare JF, Mollitt DL, DiScala C, Koeppel B, Tepas JI. Death from pelvic fracture: children are different. *J Pediatr Surg.* 1996;31(1):82–85
24. Demetriades D, Murray J, Martin M, et al. Pedestrians injured by automobiles: relationship of age to injury type and severity. *J Am Coll Surg.* 2004;199(3):382–387
25. Demetriades D, Murray J, Brown C, et al. High-level falls: type and severity of injuries and survival outcome according to age. *J Trauma.* 2005;58(2):342–345
26. Flaada JT, Leibson CL, Mandrekar JN, et al. Relative risk of mortality after traumatic brain injury: a population-based study of the role of age and injury severity. *J Neurotrauma.* 2007;24(3):435–445
27. Bensard DD, McIntyre RC, Moore EE, Moore FA. A critical analysis of acutely injured children managed in an adult level I trauma center. *J Pediatr Surg.* 1994;29(1):11–18
28. Fortune JB, Sanchez J, Graca L, et al. A pediatric trauma center without a pediatric surgeon: a four-year outcome analysis. *J Trauma.* 1992;33(1):130–137
29. Knudson MM, Shagoury C, Lewis FR. Can adult trauma surgeons care for injured children. *J Trauma.* 1992;32(6):729–737; discussion 737–739
30. Rhodes M, Smith S, Boorse D. Pediatric trauma patients in an "adult" trauma center. *J Trauma.* 1993;35(3):384–392
31. D'Amelio L, Hammond J. "Adult" trauma surgeons with pediatric commitment: a logical solution to the pediatric trauma manpower problem. *Am Surg.* 1995;61(11):968–974
32. Odetola FO, Miller WC, Davis MM, Bratton SL. The relationship between the location of pediatric intensive care unit facilities and child death from trauma: a country-level ecologic study. *J Pediatr.* 2005;147(1):74–77
33. Potoka DA, Schall LC, Ford HR. Improved functional outcome for severely injured children treated at pediatric trauma centers. *J Trauma.* 2001;51(5):824–834
34. Potoka DA, Schall LC, Gardner MJ, Stafford PW, Peitzman AB, Ford HR. Impact of pediatric trauma centers on mortality in a statewide system. *J Trauma.* 2000;49(2):237–245
35. Densmore JC, Lim HJ, Oldham KT, Guice KS. Outcomes and delivery of care in pediatric injury. *J Pediatr Surg.* 2006;41(1):92–98
36. American Academy of Pediatrics, Section on Orthopaedics, Committee on Pediatric Emergency Medicine, et al. Management of pediatric trauma. *Pediatrics.* 2008;121(4):849–854
37. Chung KK, Grathwohl KW, Poropatich RK, Wolf SE, Holcomb JB. Robotic telepresence: past, present, and future. *J Cardiothorac Vasc Anesth.* 2007;21(4):593–596
38. Field Manual 3.0 Operations. Headquarters, Department of the Army; 2008. Available at: http://downloads.army.mil/fm3-0/FM3-0.pdf. Accessed April 4, 2008